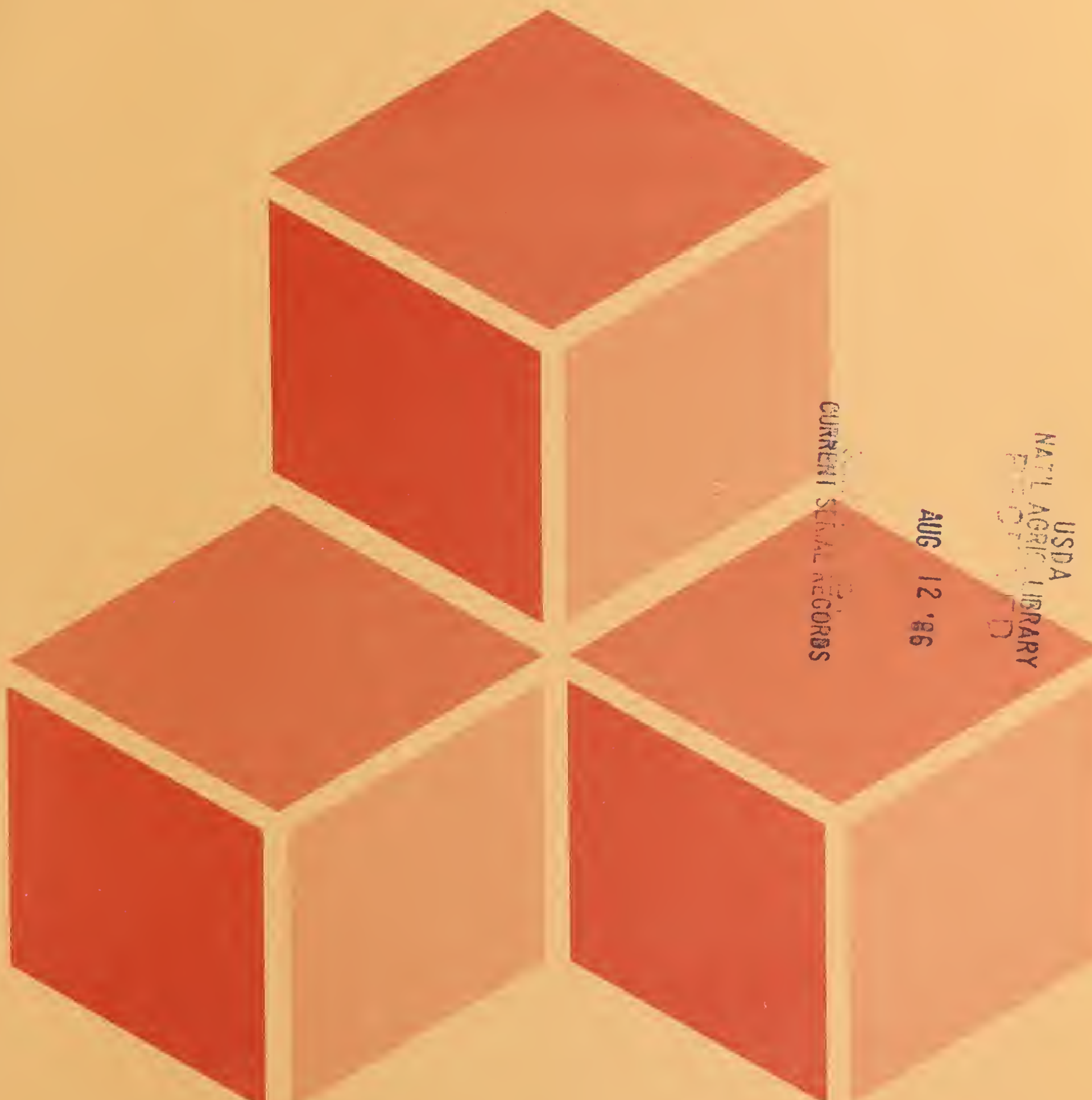
United States
Department of
Agriculture

Economic
Research
Service

Foreign
Agricultural
Economic
Report
Number 207

Energy's Role in Western Europe's Agriculture

Ruth Elleson



Energy's Role in Western Europe's Agriculture. By Ruth Elleson. International Economics Division, Economic Research Service, U.S. Department of Agriculture. Foreign Agricultural Economic Report No. 207.

Abstract

The 1973-80 oil price increases did not significantly alter the structure of Western Europe's agricultural sector or the flow of agricultural exports to the region. Energy costs represent a relatively small percentage of total input costs, with the greenhouse sector the only exception. As long as European Community policy continues to support agricultural prices, future energy crises are not likely to significantly affect the structure and performance of the region's agriculture. Biomass from farm waste and surplus crops can provide only a small part of agriculture's energy requirements, and energy crops may never be economically viable.

Keywords: Energy, Western Europe, European Community, European agriculture

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Washington, D.C. 20250 November 1984

Glossary

CAP—Common Agricultural Policy of the European Community.

ECU—European Currency Unit. On April 9, 1979, the ECU became the standard value for transactions within the CAP, including the determination of support prices, import levies, and export subsidies. The value of the ECU was calculated from a weighted basket of all EC-10 member currencies and equal to about 98 cents during 1982.

European Community (EC)—

Original six members:
- Germany (West)
- France
- Italy
- Netherlands
- Belgium
- Luxembourg

Members since January 1973:
- United Kingdom (England, Scotland, Wales, and Northern Ireland)
- Ireland
- Denmark

Member since January 1981:
- Greece

Proposed members:
- Portugal
- Spain

Other Western Europe—

- Norway
- Finland
- Switzerland
- Sweden
- Austria

Unless otherwise specified, the discussion in this report of the EC's past energy consumption patterns and other aspects excludes Greece.

Conversion Chart

This report uses metric units throughout. Metric tons will be referred to as "tons."

1 ha (hectare) = 2.47 acres.
1 kg (kilogram) = 2.2 pounds.
1 km (kilometer) = 0.6 mile.
1 liter = 1.05 quarts.
1 millimeter = 0.04 inch.
1 metric ton = 2,204.62 pounds.

1 Btu = one British thermal unit.
1 toe (metric ton of oil equivalent) = 40×10^6 Btu.
1 mtoe (million metric tons of oil equivalent) = 40×10^{12} Btu.
1 kcal (kilocalorie) = 3.968 Btu.
1 tcal (teracalorie) = 3.968×10^9 Btu.
1 g (gram) of oil equivalent = 39.68 Btu.
1 kWh (kilowatthour) = 3,412 Btu.

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Summary

The sharp increases in crude oil prices during 1973-80 did not alter the basic structure of Western European agriculture or its agricultural trade patterns.

Another oil crisis, however, may have greater impact on the cost to agriculture of both fuel and energy-containing inputs, such as feeds, fertilizers, and machinery. This is because the price of crude oil has become a larger component in the cost of manufactured petroleum and products, making them more sensitive to changes in the price of crude oil.

Energy use in the region's agricultural sector during 1973-80 showed no significant response to rising oil prices. Shocks to the sector were cushioned by relatively modest energy price increases to final consumers, the small share of energy in total agricultural input costs, and the European Community (EC) price guarantees for major agricultural products.

Agriculture uses two main types of energy: direct and indirect. Direct energy is used to operate machinery and generate heat. Indirect energy is used in the manufacture of fertilizers, feedstuffs, machinery, and other consumable agricultural inputs. Only very rough estimates of the proportions consumed in the region's agriculture are available. One such estimate places the proportions at one-third direct and two-thirds indirect.

The price of direct energy rose more than any other consumable agricultural input during 1973-80. However, because direct energy comprised only 7-8 percent of total agricultural inputs, its cost was not decisive in production decisions. Direct energy consumption is highest in Germany with highly mechanized intensive production and lowest in Ireland.

Animal production is generally more energy intensive than crop production, and energy use decreases per unit of output as farm size grows. Horticulture is by far the most intensive user of energy—30-50 percent of total input cost—and the most sensitive to energy price changes.

The principal sources of direct energy used in Western European agriculture are petroleum products, electricity, and natural gas. Although the degree of energy self-sufficiency varies among countries, the region is highly dependent on imported energy, primarily crude oil. The consumption of electricity and natural gas rose more than petroleum products during 1973-80 because of slower price increases.

Government energy policies have focused on encouraging energy efficiency and conservation, shifting to nonpetroleum-based energy, and developing alternative energy sources, such as biomass (farm waste, surplus crops, and crops used specifically for energy purposes). Small-scale biomass operations currently produce very limited amounts of energy from agricultural waste. The use of crop and animal wastes, even if economically viable, will not materially reduce agriculture's dependence on imported oil. The production of crops specifically for energy purposes is theoretically possible, but is not an economically viable substitute for current crop and livestock production.

The region's farmers began conserving energy in 1973 by reducing waste and using more efficient agricultural methods. Data, however, are not available on the exact amount saved. In general, only very limited energy savings can be realized in the region because of the many small holdings with high energy requirements and the EC's price support policies.

Energy's Role in Western Europe's Agriculture

Ruth Elleson

Introduction

Since 1973, the world economy has gone through two major energy crises caused by disruptions in the Middle Eastern oil supply. Oil prices escalated sharply, imposing a financial drain on oil importing countries. The industrialized economies of Western Europe, unable to absorb these shocks, suffered two periods of inflation and depressed economic activity.

A recent study by the International Energy Agency concluded that the world energy problem is likely to reappear in the late eighties or early nineties, with oil prices again rising sharply. The demand for imported oil is expected to accelerate by the mideighties as world economic expansion gains momentum. At the same time, oil production may level off or decline in North America, the North Sea, and the Soviet Union. As oil markets tighten, the Middle Eastern oil supply may once again become erratic (*22*).[1]

Because Western European agriculture is highly dependent on the availability of imported oil and on the price of oil-based agricultural inputs, the role of energy in the sector seemed worthy of investigation despite extremely limited statistics and economic analyses.

This study organizes available information on the role of energy in Western European agriculture, describes current views and activities relating to energy, and performs rudimentary analyses. Topics covered are the physical flow of energy through the region's agricultural sector, the effects of rising energy prices, the development of alternative sources of energy, and the role of energy in the structure and performance of the region's agriculture. The study, finding that the 1973-80 oil crisis had little effect on the basic structure of Western Europe's agriculture or on the area's international trade patterns, emphasizes the need for more comprehensive data and further research.

Trends in Energy Consumption

Total energy consumption per hectare (ha) in Western European agriculture is high compared with that of some regions of the world. Energy, however, accounts for a relatively small percentage of total input costs.

Energy-Intensive Agriculture

Agriculture in much of Western Europe is intensive, modern, and industrial with relatively high energy requirements, making the region's agricultural sector one of the most productive in the world. The consumption of direct energy in the form of fuel and electrical power parallels the high level of mechanization, and the consumption of indirect (incorporated) energy parallels the widespread use of fertilizers and agricultural chemicals.

The trend toward intensive farming has proceeded rapidly since the early fifties. The decline in the number of agricultural workers is more than offset by the adoption of labor-saving machinery, and the decline in the number of hectares devoted to agriculture is more than offset by the use of fertilizers and crop protection products. Yields per hectare have risen rapidly.

Approximately 7-8 percent of agricultural input values in the European Community (EC) are direct energy inputs (table 1). Changes in these percentages during the seventies were minimal despite rising energy costs. West Germany consumes the largest percentage of direct energy—approximately 13 percent of the value

[1]Italicized numbers in parentheses refer to items listed in the bibliography.

of total inputs—mainly due to the country's high degree of mechanization and the intensive pig and poultry sectors (*13*).

Because meat production is highly energy intensive, energy could be saved if consumers eat more cereals and less meat and animal products. Wheat contains sufficient protein to enable an adult to live in good health almost entirely on bread, with only small additions of other foods to provide vitamins and essential minerals. Such a diet is unattractive, however. High meat prices reflect the large amounts of energy needed to produce the meat, but these high prices do not deter meat consumption. In developed nations, such as those in Western Europe, diet is an important part of the general standard of living and is not likely to change (*28*).

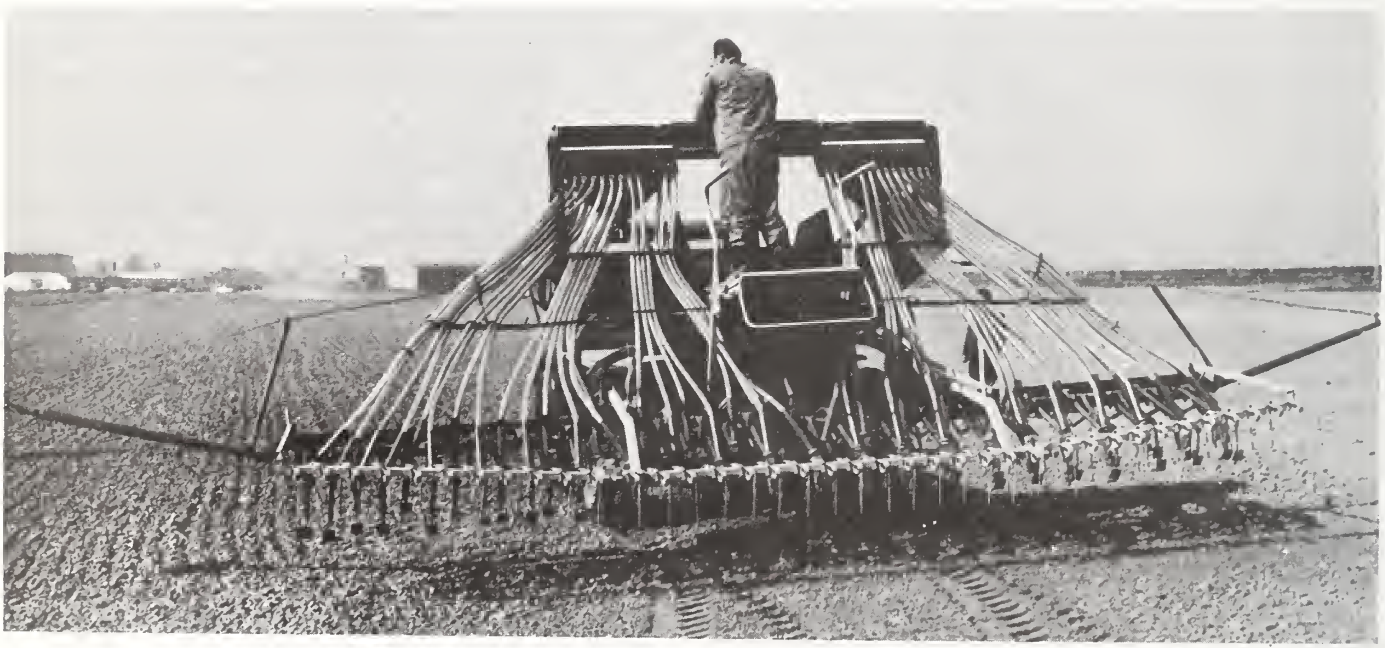
A study concluded that the EC could save energy by importing all of its beef and mutton from Argentina, Australia, and New Zealand, where cereals for feed are grown and animals are reared on large tracts of land with relatively small energy input (*26*). Such a change in policy would require major adjustments in the structure of agriculture both in the EC and in the exporting countries. In fact, increased demand may cause the exporting countries eventually to intensify their agricultural systems and to increase their energy consumption.

A more viable and less disruptive solution may be for the EC to continue present meat production and to import larger amounts of energy-intensive feedstuffs from current suppliers, including the United States. Since feedstuffs are the most important input in the livestock industry and the most energy intensive, increasing such imports would conserve domestic energy.

Sources of Agricultural Energy

The principal sources of energy consumed in Western European agriculture are petroleum products, electricity, and natural gas (table 2). Energy consumption increased during 1973-80 in virtually all fuel categories, except kerosene and residual fuel oil. The rapid gains in the use of electricity and natural gas indicate a movement away from the more expensive petroleum products.

Petroleum is the most important source of agricultural energy in all EC countries, except the Netherlands



Cultivation operations like this one in West Germany consume significant amounts of petroleum products.

Table 1—EC: Value of direct energy consumption in agricultural production, 1974–79 (1975 prices and exchange rates)

Country and year	Energy consumption	Total inputs[1]	Column 1 divided by column 2
	--------*Million ECU*--------		*Percent*
Belgium:			
1974	105	1,653	0.064
1976	109	1,668	.065
1979	116	1,676	.069
Denmark:			
1974	80	1,435	.056
1976	83	1,665	.050
1979	115	2,004	.057
France:			
1974	451	8,178	.055
1976	445	8,355	.053
1979	480	9,649	.050
Germany:			
1974	993	7,043	.141
1976	1,026	7,682	.134
1979	1,123	8,723	.129
Ireland:			
1974	43	558	.077
1976	45	586	.077
1979	57	849	.067
Italy:			
1974	248	4,247	.058
1976	259	4,538	.057
1979	291	5,380	.054
Luxembourg:			
1974	3	37	.081
1976	3	41	.073
1979	3	35	.086
Netherlands:			
1974	175	2,833	.062
1976	172	3,062	.056
1979	201	3,557	.057
United Kingdom:			
1974	329	4,589	.072
1976	323	4,682	.069
1979	351	4,763	.074
EC total:			
1974	2,427	30,573	.079
1976	2,465	32,279	.076
1979	2,737	36,636	.075

[1] Including energy.

Source: *(11)*.

(table 3). In Ireland, Italy, and Denmark, petroleum products account for at least 90 percent of direct energy consumption. In France, Germany, and the United Kingdom, the percentage is slightly lower, between 80 and 90 percent. In the Netherlands, however, only 15 percent of direct agricultural energy is supplied by petroleum products, while over 80 percent is supplied by the country's own natural gas deposits.

France's consumption of petroleum products is high at 89 percent of total energy inputs, but because the gas category consists mainly of liquefied petroleum gas, the percentage is actually over 90 percent. France's growth in the consumption of petroleum-based fuels increased at an average annual rate of 1.5 percent between 1974-78 (table 4) (*18*).

The Netherlands' substitution of natural gas for heavy fuel oil in its greenhouses has greatly limited the overall growth of oil consumption in the EC.

In the United Kingdom, oil consumption in greenhouses declined from 469,000 toe in 1970 to 263,000 toe in 1977. Tomatoes and vegetables account for 73 percent of the greenhouse area in England and Wales. The production of tomatoes increased during the seventies, but consumption of fuel oil for heating actually decreased over 20 percent. High fuel costs forced growers to make their heating systems more efficient. Although heating greenhouses with coal is cheaper, oil is cleaner, and the cost of changing to coal-fired equipment is not economically feasible (6).

Structure of Energy Consumption

A recent study for the European Communities Commission estimated direct and indirect energy use in EC agriculture at 33 and 67 percent, respectively, during 1977-78. The proportions differed considerably for individual countries (table 5) (6).

An Organisation for Economic Co-operation and Development (OECD) study estimated direct energy use in Denmark at 45 percent and indirect at 55 percent (these percentages were 38 and 62, respectively, in the EC study). The study estimated direct energy use in Spain at 90 percent and indirect at 10 percent (see figure) (*18*).

Table 2—Western Europe: Sources of energy consumed in agriculture, 1973-80

Year	Petroleum products: Liquefied gases	Motor gasoline	Kerosene	Gas/diesel oil	Residual fuel oil	Total	Electricity	Natural gas	Total energy consumed[1]
	1,000 tons						*Mil. kWh*	*Tcal*	*Mtoe*
1973	207	383	399	12,228	1,529	14,746	17,926	—	16.52
1974	201	320	382	12,646	1,340	14,889	19,671	—	17.02
1975	188	418	126	12,788	1,435	14,955	20,048	—	16.89
1976	194	392	121	12,342	1,476	14,525	21,056	55	16.92
1977	225	405	109	12,230	1,617	14,586	22,075	152	17.04
1978	331	477	83	13,031	1,690	15,612	23,472	243	18.22
1979	331	462	81	13,710	1,775	16,359	22,896	280	18.87
1980	340	456	75	13,304	1,320	15,495	23,014	262	18.02

— = Not available. [1]Excludes natural gas and includes solid fuels.

Source: *(21)*.

Table 3—EC: Direct energy consumption by type of fuel, 1977-78[1]

Country	Petroleum products: *1,000 toe*	Petroleum products: *Percent*	Gas: *1,000 toe*	Gas: *Percent*	Electricity: *1,000 toe*	Electricity: *Percent*
Belgium	702	77	48	5	161	18
Denmark	682	90	—	—	77	10
France	4,355	89	175	4	310	6
Germany	3,706	85	—	—	505	11
Ireland	345	92	—	—	32	8
Italy	1,962	90	12	1	194	9
Luxembourg	15	71	—	—	6	29
Netherlands	400	15	2,100	81	100	4
United Kingdom	1,474	80	—	—	345	19
EC total	13,641	76	2,335	13	1,730	9

Country	Solid fuels: *1,000 toe*	Solid fuels: *Percent*	Other[2]: *1,000 toe*	Other[2]: *Percent*	Total: *1,000 toe*	Total: *Percent*
Belgium	—	—	—	—	911	100
Denmark	—	—	—	—	759	100
France	—	—	60	1	4,900	100
Germany	90	2	79	2	4,380	100
Ireland	—	—	—	—	377	100
Italy	—	—	—	—	2,168	100
Luxembourg	—	—	—	—	21	100
Netherlands	—	—	—	—	2,600	100
United Kingdom	20	1	—	—	1,839	100
EC total	110	1	139	1	17,955	100

— = Not available or not significant. [1]Estimates based on national totals for 1977 or 1978. [2]Includes some solid fuels and lubricants.

Source: *(6)*.

Direct Energy Consumption. Machinery and power account for roughly half of the direct energy consumed in EC agriculture; horticulture, heating and ventilation of livestock housing, and crop drying account for the other half (table 6). The one outstanding exception is the Netherlands, where about 80 percent of direct energy is consumed in horticulture.

Cultivation operations consume the most direct energy, about 25 percent of the total in Western Europe. The extent of other direct consumption varies according to the country: 10.1 percent for irrigation in Spain, 8.9 percent for cereal drying in France, and 7.6 percent for the greenhouse sector in Finland (*18*).

The intensive pig and poultry sectors of Germany, the Netherlands, Italy, and Denmark consume approximately 50 percent of total agricultural electricity. The requirements are particularly high for incubating, heating, ventilating, and lighting. Dairy farming consumes approximately 25-35 percent of total electricity (*14*).

Horticulture accounts for almost 30 percent of total direct energy consumed in the EC. Energy consumption per unit of greenhouse area is high in such northern countries as Sweden, Finland, and Denmark, and somewhat lower in Belgium, Switzerland, and France (*7*).

Indirect Energy Consumption. Over 90 percent of indirect energy consumed in Western European agriculture is used for fertilizers, feedstuffs, machinery, and agrochemicals, such as plant protection products, her-

Table 4—France: Rate of change in agricultural energy consumption,[1] 1974-78

Source of energy	1974	1975	1976	1977	1978	Average annual growth
			Percent			
Petroleum-based fuels	1.3	−6.5	3.9	3.3	6.1	1.5
Electricity	6.4	3.1	8.3	−5.1	12.5	4.5
Total	1.5	−6.2	4.0	3.0	6.4	1.7

[1]Change in volume consumed over previous year.

Source: (*6*).

Table 5—EC: Direct and indirect energy consumption in agriculture, 1977-78[1]

Country	Direct energy		Indirect energy		Total	
	1,000 toe	*Percent*	*1,000 toe*	*Percent*	*1,000 toe*	*Percent*
Belgium	911	28	2,382	72	3,293	100
Denmark	759	38	1,260	62	2,019	100
France	4,900	36	8,800	64	13,700	100
Germany	4,380	43	5,887	57	10,267	100
Ireland	377	26	1,086	74	1,463	100
Italy	2,168	22	7,751	78	9,919	100
Luxembourg	21	20	85	80	106	100
Netherlands	2,600	47	2,981	53	5,581	100
United Kingdom	1,839	25	5,466	75	7,305	100
EC total	17,955	33	35,698	67	53,653	100

[1]Estimates based on national totals for 1977 or 1978.

Source: (*6*).

bicides, and pharmaceuticals (table 7). The manufacture of all such products requires energy, which is used indirectly in agricultural production.

Fertilizers. Fertilizers account for the largest portion of indirect energy consumed in Western European agriculture. Consumption increased rapidly during the seventies, with an especially rapid rise in energy-intensive nitrogenous fertilizers (table 8). As a result of excess plant capacity, the price of nitrogenous fertilizers paralleled the general inflation rate rather than the price of energy. Phosphate- and potash-based fertilizers, usually mined as natural products, require only small amounts of energy (*14*).

Feedstuffs. Animal feedstuffs account for the second largest portion of indirect energy used in Western European agriculture. Energy contained in feedstuffs represents approximately 40-60 percent of the total energy required for meat production, 90 percent for egg production, and about 60 percent for milk production (*7*).

The region imports a high percentage of the grains and oilseeds used in the manufacture of feed concentrates. Such imports can be considered free in terms of energy to the importing country, and in some countries, the amount of imports can be sizable. In the Netherlands in 1977, 88 percent of the fodder units contained in feedstuffs were of foreign origin. The percentages were also high for Germany, Belgium, Italy, Denmark, and the United Kingdom (*18*).

The United States, a leading supplier of feedstuffs to the EC, had a 40.9-percent supplier share of the EC market during 1977-79. This share compares with 26.5 percent for all intra-EC trade, of which France—the largest EC supplier—contributed 11.4 percent (*16*).

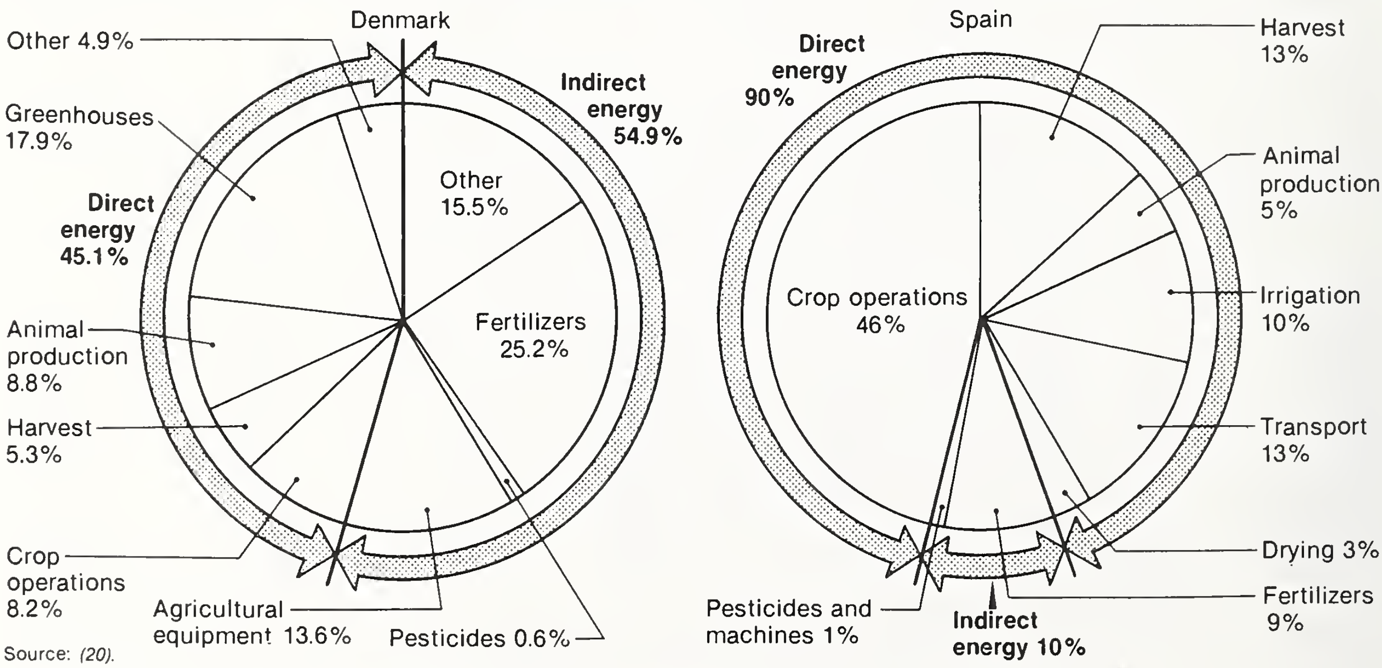
Energy Consumption by Commodity

Most of the energy consumed by agriculture is used in crop production, but a large share of the output is destined for animal production. In 1975, France and Denmark used about 66 percent of crop production as animal feed (*18*).

Crop Production. Energy requirements differ significantly from one crop to another (table 9). Some cereals need twice as much energy per kilogram (kg) as potatoes but 10-12 times less than cotton or tobacco. Fertilizers for crops grown in the open contain

Figure 1

Energy Use in Agriculture in Denmark and Spain, 1978



Source: (*20*).

Table 6—EC: Direct energy consumption by use, 1977-78[1]

Country	Heating[2]		Horticulture		Machinery and power		Total	
	1,000 toe	*Percent*	*1,000 toe*	*Percent*	*1,000 toe*	*Percent*	*1,000 toe*	*Percent*
Belgium	240	26	380	42	291	32	911	100
Denmark	79	10	350	46	330	44	759	100
France	980	20	490	10	3,430	70	4,900	100
Germany	1,100	25	1,280	29	2,000	46	4,380	100
Ireland	54	14	61	16	262	70	377	100
Italy	434	20	100	5	1,634	75	2,168	100
Luxembourg	11	52	—	—	10	48	21	100
Netherlands	200	8	2,100	80	300	12	2,600	100
United Kingdom	490	27	400	22	949	51	1,839	100
EC total	3,588	20	5,161	29	9,206	51	17,955	100

— = Not available or not significant. [1]Estimates based on national totals for 1977 or 1978. [2]Heating and ventilation used for livestock housing and crop drying.

Source: *(6)*.

Table 7—EC: Indirect energy consumption in agriculture, 1977-78[1]

Country	Fertilizer		Animal feedstuffs		Agrochemicals	
	1,000 toe	*Percent*	*1,000 toe*	*Percent*	*1,000 toe*	*Percent*
Belgium	392	17	1,464	61	—	—
Denmark	693	55	341	27	26	2
France	3,900	44	1,800	20	600	7
Germany	3,077	52	1,286	22	66	1
Ireland	496	46	200	18	—	—
Italy	4,081	53	2,550	33	706	9
Luxembourg	25	29	40	47	—	—
Netherlands	751	25	2,000	67	30	1
United Kingdom	2,228	41	1,254	23	203	4
EC total	15,643	44	10,935	31	1,631	4

Country	Machinery		Other		Total	
	1,000 toe	*Percent*	*1,000 toe*	*Percent*	*1,000 toe*	*Percent*
Belgium	197	8	329[2]	14	2,382	100
Denmark	200	16	—	—	1,260	100
France	1,300	15	1,200[3]	14	8,800	100
Germany	1,458	25	—	—	5,887	100
Ireland	195	18	195[4]	18	1,086	100
Italy	414	5	—	—	7,751	100
Luxembourg	20	24	—	—	85	100
Netherlands	200	7	—	—	2,981	100
United Kingdom	950	17	831	15	5,466	100
EC total	4,934	14	2,555	7	35,698	100

— = Not available or not significant. [1]Estimates based on national totals for 1977 or 1978. [2]Including agricultural chemicals and buildings. [3]Including buildings and miscellaneous items. [4]Including buildings, transport, and services.

Source: *(6)*.

more energy than any other single input. Nitrogenous fertilizers alone represent roughly 50 percent of the energy requirements for wheat and barley and 40 percent for potatoes. Corn drying accounts for 50 percent of total corn energy requirements (*18*).

Energy consumption also varies for the same crop, depending upon climate and production systems. More intensive methods, such as drying or irrigating, greatly increase the amount of energy required for the same commodity. Even though irrigation leads to greater energy consumption per unit of product, its use usually makes other inputs—fertilizers or the sun—more productive. Likewise, fertilizers are very costly in terms of energy, but they improve the productivity of land and labor. The increase in the fertilizer level in the United Kingdom between 1950 and 1970 contributed to increased yields and provided four to five times more food energy than the amount of fossil energy used to produce the fertilizers (6).

Attempts to alter the effects of climate are always expensive in terms of energy. In the south of France, 1 kg of in-season potatoes requires 50 grams (g) of fuel oil equivalent, 65 g for early potatoes, and 78 g for late-season potatoes. The extreme case of altering climate is greenhouse agriculture where energy consumption is about 300 tons of fuel oil per ha in a temperate Atlantic climate, 450 or 500 tons in Germany, and as high as 600 or 700 tons in Scandinavia (6).

Animal Production. The livestock sector is much more energy intensive than the crop sector when the energy content of feedstuffs is included. Much of the pig and poultry production and, to a lesser extent, cattle rearing is intensive, with animals confined in small areas and fed processed feedstuffs. This method requires direct energy for heating, ventilating, and incubating, and indirect energy in the form of feedstuffs. There is little extensive animal rearing (grazing on the open range) in Western Europe because of the limited land area. Major exceptions are cattle grazing in the United Kingdom and Ireland and sheep grazing in some of Western Europe's highland areas.

Meat production in the EC increased substantially in the sixties and seventies. As a result, demand for incorporated energy in the form of feedstuffs expanded rapidly.

In the late seventies, Rasmussen and Nielsen estimated total energy inputs (direct and indirect) in the Danish

Table 8—EC 10: Fertilizer consumption, 1969-70 and 1979-80

Country	1969-70[1]				1979-80[1]			
	Nitrogen	Phosphate	Potash	Total	Nitrogen	Phosphate	Potash	Total
				1,000 tons				
Belgium	182	145	187	514	185	101	165	451
Denmark	271	127	183	581	394	133	171	698
France	1,230	1,710	1,280	4,220	2,221	1,984	1,786	5,991
Germany	1,085	857	1,120	3,062	1,477	913	1,206	3,596
Greece	145	107	13	265	301	182	34	517
Ireland	70	167	139	376	248	156	189	593
Italy	550	486	195	1,231	1,047	718	390	2,155
Luxembourg	10	7	8	25	14	7	8	29
Netherlands	387	108	122	617	486	84	124	694
United Kingdom	796	470	419	1,685	1,314	446	461	2,221
EC total	4,726	4,184	3,666	12,576	7,687	4,724	4,534	16,945
				Mtoe				
Total energy input	7.5	1.3	0.6	9.4	12.3	1.4	0.8	14.5

[1]Agricultural year.

Sources: *(7, 13)*.

livestock industry. They found that energy input per 100 kg was 271 kcal 10^4 for beef, 56 for pork, and 46 for broiler hens. These figures compare with only 8 kcal 10^4 per 100 kg of grain (tables 10, 11, 12, 13) (6).

Energy Prices

Energy prices and Western European agriculture have been the subject of studies and articles since the first oil price rise in 1973. Rigorous quantitative studies of the impact of higher energy prices on the region's agricultural sector, however, have not been undertaken because of limited data and methodological problems.

An extremely complex econometric model constructed at Iowa State University in 1976 showed irrigation to be very sensitive to higher energy prices in the United States (4). No comparable model has been constructed for Western Europe.

The more energy used, the greater the impact of rising energy prices. In Western Europe, the share of energy costs varies greatly among regions, commodities, and types of farms.

The worldwide recession beginning in the early eighties reduced the demand for oil and caused the dollar price of oil to ease. However, because the dollar appreciated in value in relation to Western European currencies and oil from Organization of Petroleum Exporting Countries (OPEC) is paid for in dollars, oil prices in the region have not appreciably benefited from the reduction in demand (*30*).

Table 9—EC: Energy consumed to produce 1 kg of selected crops

Crop	Range in grams of oil equivalent
Wheat, barley, corn, soybeans	25-80
Sugar beets	20
Potatoes	50
Green peas	50–70
Lettuce under glass (winter)	5,000–6,000
Open-air lettuce	45
Cotton	1,350
Tobacco	1,600
Fodder silage	95–105

Source: *(18)*.

Table 10—Denmark: Energy inputs in cattle rearing,[1] 1977-78

Inputs	Energy
	Kcal 10^4
Diesel fuel	14
Electricity	28
Grain	52
Processed feedstuffs	150
Fodder beet	128
Grass	164
Straw	3
Total	539
Energy input per 100 kg of milk	10
Energy input per 100 kg of meat	271

[1]Input per cow with young stock.

Source: *(6)*.

Table 11—Denmark: Energy inputs in pig rearing,[1] 1977-78

Inputs	Energy
	Kcal 10^4
Fuel oil	43
Diesel fuel	10
Electricity	49
Grain	393
Processed feedstuffs	196
Straw	3
Total	694
Energy input per 100 kg of meat	56

[1]Input per 17.7 bacon pigs.

Source: *(6)*.

Table 12—Denmark: Energy inputs in broiler rearing,[1] 1977-78

Inputs	Energy
	Kcal 10^4
Fuel oil	9
Electricity	3
Feed	37
Total	49
Energy input per 100 kg of meat	46

[1]Input per 100 broilers.

Source: *(6)*.

Energy Inputs

Energy inputs to an agricultural system may be in the form of direct energy, such as petroleum and electricity; manufactured products, such as fertilizers, chemicals, and machinery; organic products, such as seed and feedstuffs; solar energy; and human energy (labor). Solar and human energy fall outside the scope of this study.

Input Prices. Agricultural input prices increased 97.4 percent during 1973-80 in the EC-10 (table 14). Energy prices registered the largest increase at 204 percent. However, energy accounts for less than 8 percent of total intermediate inputs, so the price increase greatly exaggerates energy's impact on the sector.

Indirect input costs are affected by the price of energy incorporated in them, but because research is virtually nonexistent in this area, no assessment of the impact on the region's agriculture can be made now.

Fertilizers. Fertilizer prices in most countries of Western Europe increased more slowly during 1973-79 than the general index of agricultural input prices. Industry excess capacity had a much more decisive effect on the price of energy-intensive nitrogenous fertilizers than the rise in energy prices (*18*).

Table 13—Denmark: Energy inputs in grain production,[1] 1977-78

Inputs	Energy
	Kcal 10^4
Diesel fuel	68
Heating fuel oil	37
Electricity	4
Nitrogen fertilizer	165
Phosphate fertilizer	13
Potash fertilizer	10
Lime	20
Agrochemicals	7
Seeds	14
Total	338
Energy input per 100 kg of grain	8

[1]Input per ha.

Source: (*6*).

The yield response of arable crops to application of nitrogenous fertilizers is approximately linear at lower application rates. At higher rates, the increase in crop yields per kg of fertilizer falls, indicating declining efficiency of incorporated energy. When considering the financial aspects, however, "buying" extra yield by using more fertilizers may still be profitable. Increasing profit may accompany decreasing energy efficiency, so reducing fertilizer application may not be in the farmer's interest (*15*).

Until 1980, Western Europe's farmers rapidly increased their use of nitrogen fertilizers despite the high energy content. They were guided by short-term productivity gains rather than the medium-term gains of phosphate and potash fertilizers with a much lower energy content (*18*).

Feedstuffs. Feedstuffs are the most important input in the livestock industry, but price depends much more on the world market situation than on the price of energy. The bulk of feed products is imported from such countries as the United States, Canada, and Australia. As a result, European livestock producers using these feeds have been affected only to a limited extent by the rising cost of energy even after transportation costs are added.

Heating, lighting, and ventilating this poultry house in southern France mean high energy costs.

Machinery and Equipment. Machinery and equipment contain incorporated energy that is reflected in the price of the equipment. But since farmers make such purchases infrequently, the effect is felt with a lag. Farmers who replace their tractors today, however, feel an immediate impact. Here again, data are lacking, so the effect of higher energy prices is not known.

Energy Inputs by Sector. Energy costs represent a relatively small percentage of total agricultural input costs, except in the greenhouse sector. Energy input costs are presented for each agricultural sector.

Greenhouse Sector. The greenhouse sector is the only sector in which adjustments to higher energy prices are visible because of the extremely high levels of energy inputs. Energy in this sector accounts for approximately 30-50 percent of total input costs. Shortly after the first major energy price rise in 1973, greenhouse operators began to reduce energy inputs by improving insulation, reducing greenhouse temperatures, changing and lengthening the growing season, and shifting to hardier plants and crops (*18*).

In Germany, the sharp increase in energy costs since 1973 has resulted in a 15- to 20-percent drop in energy inputs in horticulture despite an increase in the area under glass. In the United Kingdom, energy inputs in the sector fell about 25 percent between 1973 and 1980. In the Netherlands, the reduction was 15 percent and accompanied an increase in the area planted to flowers to the detriment of vegetables. Greenhouses may eventually be displaced to warmer regions of Europe where tomatoes, lettuce, and other vegetables are grown with very little supplemental energy even in winter (*18*).

Other Sectors. Reactions to higher energy prices are not as clear for other types of agricultural production. No studies have been undertaken to determine what changes, if any, have been made. In general, farmers in a market economy plan inputs to maximize output and net income, and energy is treated like any other input. Total costs influence farmers' decisions more than any other factor. Thus, while energy efficiency constitutes a criterion for decisionmaking, farmers do not consider this factor exclusively (*18*).

Furthermore, fossil energy is not the only scarce factor used in agricultural production. Land, certain minerals, water, labor, capital, and so forth can be locally or globally more scarce and just as vital to agricultural output. Microeconomic analysis, therefore, is still valid in determining the proper proportions of each input to use in producing a particular product. Energy inputs will be increased to the point where the value of the marginal product equals the value of the marginal product of all other inputs. Below this level, income and output will not be maximized.

The energy consumed for a given value of product varies considerably according to commodity. In livestock production, for example, producing 1 kg of beef takes some 20 times more energy than producing 1 kg of corn. But price differences make the proportion of energy costs approximately the same for each commodity. Greenhouse vegetables and vegetables grown in the open are also quite different in energy content, but here again, the amount of energy used tends to be in proportion to the price (*18*).

Input-Output Ratios. A number of writers have compared the ratio of energy inputs to energy outputs for different commodities (E ratios). On this basis, arable enterprises use energy more efficiently than livestock enterprises. If the optimization of E ratios was the sole criterion for enterprise choice, arable crops used directly for human consumption would be grown on as much land as possible with livestock and feedstuffs using areas unsuitable for these crops. Commercial farmers, however, are more concerned with maximizing the returns from their businesses than with maximizing E ratios (*15*).

Energy Productivity. Almost all the modern techniques by which agriculture has improved its productivity have depended upon inputs of energy in the form of fuels, machinery, chemicals, and fertilizers. The level of current productivity is far greater than could be achieved solely by the labor of humans and animals.

Any requirement to systematically reduce energy inputs in the agricultural sector in order to conserve energy is not practical since the sector produces more energy in terms of food than it consumes. In addition, the export of agricultural products earns foreign exchange needed to purchase oil on the international market. Nevertheless, energy costs are becoming an increasingly important factor, and the agricultural industry should economize wherever possible (*18*).

Table 14—EC 10: Price increases[1] and weighting schemes[2] for energy and other selected inputs consumed in agriculture, 1973-80

Inputs	EC total		Germany		France		Italy		Netherlands		Belgium	
	Percentage price increase	Weight	Percentage price increase	Weight	Percentage price increase	Weight	Percentage price increase	Weight	Percentage price increase	Weight	Percentage price increase	Weight
							Percent					
Seeds	118.4	3.9	55.3	2.2	140.5	5.8	141.8	3.2	29.4	2.4	65.8	3.7
Animals for rearing and production	123.0	1.9	15.0	.6	36.8	.5	93.4[3]	8.4	25.4	.5	21.2	2.3
Energy, lubricants	204.0	8.0	105.0	13.2	258.6	5.5	310.6	5.7	215.9	6.0	188.0	6.1
Fertilizers, soil improvers	130.9	14.5	51.4	15.6	152.2	20.9	281.6	9.1	54.9	7.3	77.9	8.7
Plant protection products	109.5	3.6	5.4	2.1	118.3	6.5	174.2	4.2	42.1	1.8	21.0	2.7
Animal feedstuffs	68.1	45.0	5.7	37.0	69.7	33.1	163.8	59.1	18.7	63.7	26.0	61.9
Material and small tools	130.7	3.1	39.2	1.2	101.5	6.4	132.0[3]	1.8	57.3	1.2	67.4	1.1
Maintenance and repair of equipment	105.4	7.5	60.0	12.2	133.1	9.2	38.9[3]	1.4	72.2	5.4	98.3	4.5
Maintenance and repair of agricultural buildings	123.6	3.2	40.4	4.4	145.7	2.8	158.8[3]	.1	84.2	2.5	109.8	.3
Veterinary services	103.2	2.2	44.2	1.2	116.8	4.1	32.1[3]	1.3	45.0	1.5	94.0	3.1
General expenses	87.3	7.1	39.2	10.3	117.3	5.2	61.7[3]	5.7	54.1	7.7	94.0	5.6
Total	97.4	100.0	36.6	100.0	115.5	100.0	176.2	100.0	36.9	100.0	46.4	100.0

See footnotes at end of table.

Continued

Table 14—EC 10: Price increases[1] and weighting schemes[2] for energy and other selected inputs consumed in agriculture, 1973-80—Continued

Inputs	Luxembourg		United Kingdom		Ireland		Denmark		Greece	
	Percentage price increase	Weight	Percentage price increase	Weight	Percentage price increase	Weight	Percentage price increase	Weight	Percentage price	Weight
					Percent					
Seeds	49.5	2.7	141.7	4.9	230.9	3.2	123.2	4.2	238.1	3.5
Animals for rearing and production	—	—	104.4	1.9	75.2	.6	—	—	114.2[3]	.4
Energy, lubricants	131.5	6.8	324.0	7.3	421.2	9.8	263.3	5.6	409.8	19.4
Fertilizers, soil improvers	68.7	15.0	192.6	12.6	240.7	22.3	125.7	14.9	172.7	12.7
Plant protection products	66.5	.9	238.1	2.2	194.9	1.3	49.2	1.8	155.5	4.1
Animal feedstuffs	30.1	49.2	120.0	46.1	158.9	41.6	53.1	48.5	175.3	40.0
Material and small tools	48.9	2.7	240.7	3.5	232.1	4.3	114.8	1.7	227.2	5.3
Maintenance and repair of equipment	105.9	8.2	184.6	6.2	253.0	5.2	110.6	6.7	244.5	7.4
Maintenance and repair of agricultural buildings	93.7	3.3	217.0	7.0	232.7	3.1	101.2	3.1	280.0	2.4
Veterinary services	91.3	2.8	183.0	1.8	174.7	4.0	60.1	2.8	—	.2
General expenses	65.1	8.4	149.9	6.5	233.5	4.6	87.8	10.7	167.4	4.6
Total	54.1	100.0	158.9	100.0	211.2	100.0	74.6	100.0	219.7	100.0

— = Not available. [1]Rates of change in price indexes. [2]Reflects the structure of relative inputs in 1975. [3]1980/75.

Source: *(12)*.

Rising Energy Prices

The impact of the significant price increases of the seventies in petroleum products consumed in Western European agriculture was moderated by much slower price rises in other forms of energy used by the sector (table 15).

These energy price increases do not take into account tax rebates or subsidies which farmers and horticulturalists in some countries received from their governments. The impact of such rebates, however, was generally not very great, so the table gives a reasonable indication of real energy price increases. The one exception was the Netherlands where the subsidy received by horticulturalists using natural gas was high. Objections to this practice by other EC countries have led to a gradual reduction in the subsidy.

The increase in the price of petroleum products paid by farmers in 1974 was much smaller than the increase in the price of crude oil. The gap was smaller in 1979 and will likely become even smaller (*18*). First, North Sea oil and other forms of energy had a restraining effect in 1974, but their effect is diminishing as prices of these energy sources are gradually catching up with the price of imported crude oil. Second, the share of primary energy in the average price of final energy has increased appreciably, rising from 25 percent in 1972 to 41 percent in 1978. The effects of an increase in primary energy prices are much more marked in the new price structure than in the old as shown in the following:

Different effects of doubling the price of crude oil[1]

	First case (1974)			Second case (1979)		
Final energy	100 →	125	+ 25%	100 →	150	+ 50%
Value added	75	75	60%	50	50	33%
Primary energy	25 →	50	40%	50 →	100	67%

[1]Assuming value added is independent of energy prices. In 1979/80, any percentage increase in oil prices led to half that percentage increase in the price of final energy.

Source: *(18)*.

Energy Consumption. Rising energy prices apparently did not affect the consumption of energy in Western European agriculture during 1973-80. No relationship was found between energy prices and the consumption of petroleum products in the EC agricultural sector, except in the United Kingdom (table 16). The significant negative correlation for the United Kingdom—consumption declined as price increased—does not prove a causal relationship between consumption and price. Factors other than price could have accounted for the relationship.

While correlation during the 8-year period did not prove significant, the data do indicate a noticeable drop in consumption in 1974 and again in 1980, the 2 years in which energy prices increased the most. These drops occurred in the EC as well as in a number of individual countries.

Impact Studies. Studies to determine the impact of higher energy prices are few in number and limited in scope. Two representative studies are highlighted below.

France. A study by Bonny in 1980 used linear programming to measure the effect of a rise in the price of energy (direct and indirect) on farm income (*1*). Bonny hypothesized that a 50-percent increase in the price of energy would result in a change in the product mix away from those products using more energy to those using less.

Based on a relatively small sample, the study found no significant change in the products produced. Good return crops continued to be produced despite higher energy costs. The income of intensive dairy farms was

Table 15—Indexes of real energy price increases, 1973-78

Country	Electricity	Gas oil	Fuel oil
	1973 = 100		
Belgium	117	111	219
France	105	179	193
Germany	100	107	173
Ireland	138	249	291
Italy	156	221	280
Netherlands	136	149	177
United Kingdom	123	248	207

Source: *(7)*.

affected less than crop farms largely because of a faster rise in yields and greater use of lower priced electricity (*1*).

Energy consumption declined somewhat on cereal farms but very little on intensive dairy farms because cereal farms have greater latitude for reducing energy consumption in the short run. Feed crops, for example, can be sun-dried instead of mechanically dried, and some immediate economizing can be implemented in tractor and fertilizer use.

Farm structure, however, severely limits reduced energy consumption in the short run. Revenue is im-

Table 16—Consumption of petroleum products and price of energy directly consumed in agriculture, selected countries, 1973–80

Country and year	Petroleum products consumed per million dollars of agricultural output	Price indexes of agricultural energy	Correlation coefficients	Country and year	Petroleum products consumed per million dollars of agricultural output	Price indexes of agricultural energy	Correlation coefficients
	Toe	*1975 = 100*			*Toe*	*1975 = 100*	
Belgium:				Italy:			
1973	368.8	62.4		1973	238.1	50.0	
1974	310.5	82.8		1974	248.9	91.5	
1975	341.8	100.0		1975	271.8	100.0	
1976	342.6	106.4	r = 0.423	1976	251.0	121.4	r = 0.417
1977	441.0	111.2		1977	265.6	147.4	
1978	446.5	110.0		1978	274.6	150.1	
1979	498.2	137.3		1979	277.3	162.5	
1980	388.3	179.7		1980	249.3	205.3	
France:				Netherlands:			
1973	280.5	60.9		1973	169.7	64.1	
1974	283.5	94.5		1974	147.5	88.4	
1975	277.7	100.0		1975	136.8	100.0	
1976	296.3	112.0	r = −0.406	1976	133.0	115.3	r = −0.082
1977	297.2	124.4		1977	137.6	127.5	
1978	304.0	133.9		1978	156.9	134.4	
1979	281.1	159.1		1979	132.5	154.2	
1980	261.0	218.4		1980	160.2	202.5	
Germany:				United Kingdom:			
1973	174.9	78.9		1973	419.0	56.3	
1974	164.7	93.9		1974	332.4	82.3	
1975	174.7	100.0		1975	357.3	100.0	
1976	178.2	107.1	r = −0.675	1976	339.9	123.1	r = −0.925
1977	163.7	107.2		1977	325.1	147.4	
1978	147.1	107.6		1978	317.5	152.1	
1979	148.8	139.4		1979	309.2	181.9	
1980	150.7	161.7		1980	226.8	238.7	
Ireland:				EC total:			
1973	335.1	47.2		1973	286.5	66.1	
1974	233.1	80.1		1974	262.9	91.0	
1975	214.3	100.0		1975	272.9	100.0	
1976	255.3	122.5	r = −0.133	1976	292.4	112.7	r = −0.064
1977	155.3	142.9		1977	292.4	122.9	
1978	217.2	138.8		1978	295.8	126.2	
1979	253.1	172.5		1979	296.2	153.4	
1980	280.6	246.0		1980	265.3	194.5	

Sources: *(21, 29, 10)*.

mediately affected when energy prices double, but no significant adjustment can be made in the short run because production techniques evolve slowly. In the long run, new techniques and equipment using less energy are likely to evolve, and energy costs will fall to a more normal proportion of total costs.

The study concluded that the price of energy has not become so prohibitive that it is the sole criterion for determining how much to use. Because our economic system is based on the value of exchange and not the value of use, the price of any one input, such as energy, does not determine what commodities to produce or what production methods to use (*1*).

The Netherlands. In 1981, a group of economists at Leiden University studied the effect of higher energy costs on Dutch dairy farms. Energy costs, direct and indirect, in the dairy sector were estimated at approximately 10 percent of total input costs with fertilizer and feed concentrates accounting for 75 percent of total energy costs (*3*).

A linear programming model was used assuming a 15-percent increase per year in energy prices and a 5-percent increase per year in other input prices. Results were obtained over periods of 2, 4, 6, 8, and 10 years. Farm income declined immediately, but no other significant change occurred until after the sixth year when the number of milk cows and milk production began to decline. Milk output per cow, however, remained constant.

The study concluded that if future energy price increases should cause imported feedstuffs to become prohibitively expensive, the Dutch dairy sector would switch from imported feed, such as corn and soybeans, to European grains and roughage. Such action would have an adverse impact on the United States, a large supplier of feedstuffs to the Netherlands. The likelihood, however, of such a development is remote. First, it is highly improbable that higher energy prices would cause the United States to lose competitive advantage. Second, it is equally improbable that European producers of grains and roughage could meet the increased demand from the Dutch dairy sector without causing sharp price increases. Third, the Dutch dairy herd would have to be replaced with breeds better able to consume large amounts of roughage, or yields would suffer (*3*).

Energy Costs by Type of Farm

Energy costs vary according to the type of production, farm structure, and the particular region or country. The large, extensive farms use less energy per ha than small, intensive ones. Higher energy costs affect smaller farms, expecially fragmented farms, much more than they do larger farms, thereby increasing income disparities within the agricultural sector.

Equal-sized farms producing products which incorporate a higher percentage of energy in their selling prices are probably more affected than those incorporating a lower percentage. In France, for example, petroleum products account for 80 percent of energy requirements on cereal farms but only 60 percent of the requirements on dairy farms. Lower cost electricity has played an important role on most of Western Europe's dairy farms.

Substantial differences in energy use also exist between farms which produce the same product but use different production methods. For example, in extensive-production countries, like Ireland and Spain, the ratio of energy cost to net value added averages about 4-5 percent for most agricultural commodities, whereas in an intensive-production country, like Germany, the ratio is around 15 percent (*18*).

Farm Income. Under a free market system, the level of farm income is determined by the capacity to pass the higher energy costs downstream to processors and consumers. Under a system of guaranteed prices, such as that of the EC countries, pressure can be brought to bear to increase prices.

The ratio between expenditures on direct energy and net income gives an idea of sensitivity of various types of farms to energy price rises. In France, for example, greenhouses and poultry farms are the most sensitive (table 17).

Energy Input Costs. Direct energy costs per farm in five major agricultural countries of Western Europe varied from a mean of $5,856 for pig and poultry farms to a mean of $1,983 for permanent crop farms (table 18).

Variance analysis was used to determine whether the observed differences in mean energy costs signify a

correlation between the dependent variable (energy cost) and the independent variable (type of farm) (table 19). The null hypothesis that average energy costs are the same in the population is rejected since the variance of energy costs among groups is 7.26 percent greater than the variance within groups, and this exceeds both 2.45 (F.05) and 3.53 (F.01). Therefore, the classification of farms according to type is valid insofar as energy costs are concerned.

According to the least significant difference (LSD) test, however, only some means stand out as being significantly different from the others. At the 5-percent level, the mean energy cost of pig and poultry farms is significantly greater than each of the other means, and the mean of field crop farms is significantly greater than that of permanent crop farms. Differences in the mean energy costs of the remaining farm types are not statistically significant at the 5-percent level.

Agricultural Trade

The increased cost of energy affects trade through supply, demand, and transportation. Little is known of the effect of energy costs in Western Europe's agricultural trade. The one exception is glasshouse crops where high energy intensity has resulted in observable shifts in trade, such as increased EC imports of Spanish lettuce and tomatoes (*18*).

Supply. On the international market, rising energy prices imply a change in comparative advantage. Energy price increases and the absolute level of energy

Table 17—France: Direct energy costs as a percentage of net income, 1978

Type of farm[1]	Percent
Crops	10.7
Dairy	11.1
Beef	10.1
Milk and beef	10.4
Horticulture	43.0
Fruits	16.4
Pork	15.4
Poultry	24.2

[1]Farms 20–50 ha, except horticulture and poultry.

Source: *(18)*.

prices vary from country to country. At the end of 1978, for example, farmers were paying 3.8 times more for petroleum products in Switzerland than in Spain. Agronomic conditions also vary among countries for a particular type of production. Differing quantities of energy, therefore, are needed per unit of product, causing differing sensitivities to rising energy prices.

The high energy cost of greenhouse products has increased the cost differentials among countries and shifted the pattern of trade in these commodities. The cost of energy for greenhouses is 2.5-3 times higher in Belgium, Germany, and Denmark than in the Netherlands (indigenous gas supplies), while production in Spain is possible in cold houses or outdoors. Up to about 1976, greenhouse production of tomatoes and lettuce, representative greenhouse products, continued

Table 18—EC: Direct energy costs per farm by type of farm, selected countries, 1980

Country	Field crops	Permanent crops	Grazing	Pigs and poultry	Mixed cropping	Mixed livestock	Crops-livestock
				Dollars			
Germany	6,324	3,599	3,272	6,738	4,364	4,180	3,772
France	3,587	1,896	1,748	6,493	1,810	2,629	2,410
Netherlands	3,062	1,409	3,295	6,611	2,283	3,590	3,642
Belgium	3,320	1,842	1,739	3,504	2,012	2,138	2,116
Denmark	2,577	1,171	2,673	5,936	2,722	2,635	2,598
Total	18,870	9,917	12,727	29,282	13,191	15,172	14,538
Mean	3,774	1,983	2,545	5,856	2,638	3,034	2,908

Source: *(9)*.

to increase in the first three countries mentioned. Since then, production in these countries has dropped by 15-30 percent, and imports have increased by 15-50 percent. At the same time, Spanish tomato exports (largely from the Canary Islands) have increased by 50 percent. Greenhouse products represent only a small proportion of trade, but more products could be involved if energy's share of total input costs continues to rise (*18*).

Demand. The increased cost of oil has weakened aggregate world demand for all imports including agricultural commodities. The demand for imported agricultural products in the industrialized countries of Western Europe, however, probably has not been affected since such products are considered necessities and account for only a small percentage of total imports.

In the long term, petroleum importing countries may seek to correct the deficit in their balance of payments either by increasing domestic food production or increasing exports of surplus commodities. The results may be negligible in view of the deteriorating terms of trade in agricultural products. In order to import 1 ton of petroleum in 1980, a country had to export six times more wheat or four times more beef than in 1972, possibly resulting in reduced overall demand for food in world markets. The increased demand for food in the OPEC countries is expected to remain small.

Transport Costs. An increase in the energy component of transport costs may reduce the competitiveness of producers located far away from their buyers and, hence, influence trade, particularly for sea transport. Transporting 1 ton of cereal from Montreal to Rotterdam is estimated to require 20 kg of oil equivalent compared with about 70 kg from Australia to the United Kingdom (including an empty return trip). The extent to which shipping costs have contributed to shifts in the patterns of world trade is unknown. Changes in rail and truck shipping costs within Western Europe and their effect on intra-European trade are also unknown (*18*).

Future Trends. A third oil crisis could have more far-reaching effects than the previous two on the region's comparative advantage and pattern of trade in agricultural commodities, largely because of the rapidly increasing share of crude oil in the cost of manufactured petroleum products. This increase could be offset, however, by EC price support policies. In addition, any shift from food crops to energy crops will disturb the current import-export equilibrium (*20*).

Table 19—Analysis of variance of direct energy cost

Source of variation	Degrees of freedom	Sum of squares	Mean square	F value[1]
Among groups	6	48,533,190	8,088,865	7.26
Within groups	28	31,190,071	1,113,931	NA
Total	34	79,723,261	NA	NA

NA = Not applicable. Note: Least significant difference is 1,367 at the 5-percent level of significance. [1]F.05 = 2.45, F.01 = 3.53

Source: Table 18.

Energy Policy

Energy policy in Western European agriculture focuses on conservation and the development of biomass. The EC and individual countries are sponsoring a number of research and development (R&D) programs, but these programs are not coordinated Communitywide.

Development of an Energy Policy

Economic growth in Western Europe over the past 30 years has greatly increased the region's dependence on imported energy, principally oil. The EC, the world's largest oil importer, has been slow to diversify energy sources. Imported oil still accounts for half of total energy consumption.

The first EC energy policy proposals were drafted in 1962, but interest waned because oil prices were low and supplies plentiful. After 1973, however, the concept of a Communitywide energy policy was revived. The sharp increases in the price of oil and the interruptions in supply showed how extremely vulnerable the region's economies had become to events in the international oil market.

Up to 1983, the EC still did not have a common energy policy. What existed was a proliferation of uncoordinated R&D energy programs at the national and Community levels. Reducing dependence on imported

oil would be better served by a Communitywide energy policy; however, agreement on such a policy has proven difficult. Nevertheless, the work of drafting an energy policy continues (*8*).

In June 1980, the Council of the European Community issued a set of guidelines on energy policy objectives for 1990. Included were guidelines to reduce oil consumption to about 40 percent of gross primary energy consumption, to increase the importance of solid fuels and nuclear energy in the generation of electricity, and to encourage the use of renewable energy, such as biomass.

Since 1975, the EC Commission has initiated and financed research projects in energy saving and in the development of renewable energy sources and of projects already underway in the areas of coal, hydrocarbons, and nuclear fission and fusion. The EC's 1979-83 energy research and development budget, almost double that of the previous budget, emphasized renewable energy and energy savings (*8*).

The contribution of renewable energy sources to the EC's energy supply was only 1.5 percent in 1980, mainly in hydroelectric power and geothermal energy. If current efforts to increase this percentage are successful, renewable energy's share could almost double by 1990, with most of the increase coming from solar energy and biomass (*8*).

The EC's energy programs initially focused on industry, transportation, and heating, the principal energy-consuming sectors. In recent years, other sectors, such as agriculture, have been included. Agricultural programs generally concern (1) how much energy the sector can save; (2) to what extent agriculture can transfer to other sources of energy; and (3) what contribution may be expected from production of energy from biomass (*18*).

Since energy efficiency does not necessarily coincide with economic efficiency, the adjustment of agriculture to these energy demands is not clear. Policy must determine how far to intervene to strike a satisfactory

A major source of biomass energy in Western Europe is waste from animals raised indoors.

balance. The degree of intervention depends not only on tradition and each country's situation but also on farm operators themselves, notably the share of energy in their total costs.

While the EC does not yet have a true energy policy, the Committee on Agriculture of the European Parliament recommended that such a policy (1) encourage the production and export of energy crops in developing countries, particularly in the African countries of the African, Caribbean, and Pacific States (ACP) linked with the EC under the Lome' Convention; (2) ensure that the EC could produce concentrated biomass at very short notice if energy supplies were cut off; and (3) encourage the use of agricultural waste (straw, manure, etc.) on the farm to reduce farmers' dependence on petroleum products.

To achieve these goals, the Committee recommended that a European center be set up for biomass research. This center would at least partially finance pilot projects in the EC and in the African ACP countries. In the Committee's opinion, such a policy may help to solve the serious energy problems of developing countries (*24*).

A number of countries have programs to develop biomass as a source of energy and to conserve energy on the farm. The French Government, for example, supports research and development of biomass energy through financial aids for selected projects, such as bio-gas, wood combustion, and gasification. German farmers recently have been integrated into a Government investment program to find new ways of economizing on energy. The governments of a number of other countries also encourage and support biomass and energy conservation projects (*23*).

Policy will be instrumental in determining the role of biomass in the form of energy crops. The relatively high prices received by farmers for producing food products in the EC and the relatively low percentage of energy costs in total expenditures give farmers little, if any, economic incentive to convert fertile land to energy crops. Also, biomass use involves substantial investment costs. Therefore, unless policy incentives are adequate, most biomass energy in the nineties will be obtained from agricultural wastes and residues. These materials are in many instances already economically feasible as a source of energy. Straw, for example, is now used in several countries, and a number of other waste materials may be viable sources of energy (*18*).

Energy Conservation

Conservation measures become more profitable as energy prices rise. Most of the adjustment takes place in the long run, but some opportunity exists to conserve energy in the short run. In Western Europe, farmers began to economize on petroleum-based inputs soon after the first oil price rise in 1973. No estimates are available, however, on the amount of energy saved. Energy conservation has been the subject of considerable research over the past decade, and many experts believe that further shifts away from the use of petroleum products will occur during the eighties (*5*).

Reduced cultivation in crop production involves techniques designed to reduce fuel oil consumption in tractor operations. Experiments have shown that the fuel required for cultivation of and drilling for cereals can be reduced 25 percent by reducing the depth of plowing and 50 percent by using a combination of a chisel, plow, and rotary cultivator. These experiments have not indicated any reduction in yield. Reduced cultivation, however, has sometimes made additional herbicide use necessary (*27*).

The Dublin Agricultural Institute and the Boxworth Experimental Station and Mechanization Institute in the United Kingdom agree that soil cultivation methods have little influence on yields and that minimum cultivation methods significantly reduce energy consumption. In Sweden, however, minimum cultivation experiments were not successful; yields fell 10-20 percent because of weed growth. Swedish scientists felt that chemical control of weeds led to high energy consumption and posed a threat to the environment. In France, experiments showed great variation in energy consumption per unit of land, depending upon the crop cultivation equipment used (*25*).

The artificial drying of grain is essential in many regions of Western Europe, especially in the United Kingdom. Fuel efficiency is, to a large extent, á function of the type of drier used, low-temperature driers being the most efficient. A switch toward this type of drier in recent years is expected to continue. How-

ever, the efficiency of low-temperature driers varies widely, and the factors that affect performance are currently being studied.

Intensive livestock production requires energy for automatic feeding, heating, ventilating, and so forth, but a major part of the energy is derived from coal rather than oil. The use of silage as feed rather than artificially dried hay reduces fuel consumption, but conventional haymaking makes maximum use of solar energy and is the most fuel efficient.

The principal uses of energy on the dairy farm are for milking machines, water heating, and milk cooling. Energy conservation research focuses primarily on milk cooling and water heating. Several types of heat recovery units available on the market are designed to preheat water by heat transfer from the high-pressure side of the bulk tank refrigerant cycle. While the economic viability of such equipment has yet to be proved, a number of farmers have already installed this equipment (*2*).

Energy conservation is also possible by reducing consumption of nitrogenous fertilizers. Legumes, such as lucerne and clover, require much smaller amounts of nitrogenous fertilizers than many other crops. Western European farmers could, therefore, save energy by growing more legumes. However, the area devoted to legumes in the three main producing countries (Germany, France, and Italy) has dropped an average of 30 percent. The principal reasons are the lack of guaranteed prices for legumes in the EC, lower yields than for some other crops, and prior to 1980, a relatively stable price for nitrogenous fertilizers (*19*).

A number of governments have set energy conservation targets for 1990. The Netherlands, for example, expects to reduce energy consumption in its agricultural sector 13 percent, and the United Kingdom expects a reduction of 31 percent. France plans energy savings of 40 percent for heating livestock buildings, 25 percent for drying and heating greenhouses, 15 percent for running tractors and agricultural machinery, and 8 percent for applying fertilizer (*18*).

Biomass

The principal sources of biomass energy in Western Europe are farm waste (crop and animal), surplus crops, and crops produced specifically for energy purposes. Some forms of the first two categories are either already or very close to being economically viable. Energy crops, however, still require considerable R&D before they can become a viable source of energy.

The EC estimates that about 5 percent of its energy requirements could be met between 1990 and 2000 by fuels produced from biomass; of this 5 percent, half would be from farm and forestry waste and the other half from energy crops (*18*).

Farm Waste. The production of energy from agricultural residues and animal waste corresponds to more intensive use of an agricultural system rather than a change in the system itself. This category of biomass, therefore, appears to be a good prospect for use as an energy source.

Crop Residues. Whether or not European farmers use a residue, such as straw, for energy purposes depends upon the residue's value or opportunity cost in various uses. For example, if farmers can sell all the straw they produce to a cellulose factory located near their farms, the value or opportunity cost of the straw is the price paid by the factory. If the value to the cellulose factory is higher than the value to a straw-burning installation, then farmers will sell the straw to the cellulose factory.

On the other hand, if farmers cannot sell the straw because there is no market, they will, no doubt, use it in some manner on their farms at a much lower value or opportunity cost. In this case, construction of a local straw-burning installation may be feasible (*17*).

Depending on the region and type of farm, several sources of biomass are sometimes available (straws, animal wastes, wood) so the economic advantages of each must be compared. Most of the current microeconomic assessments relate to a predetermined project; the choice between possible alternatives is rarely dealt with on an economic basis. The assessments usually do not take sufficient account of the side effects of setting up such a plant and are very often based on a single criterion: the time it takes to break even on the investment. This tends to favor small-scale investment which may be profitable sooner than large-scale investment (*17*).

The Svendborg Heating Center in Denmark consumes 14,000 tons of straw a year supplied by 17 enterprises

(10 harvesting contractors and 7 farmers). The harvesting and transport costs represent about 70 percent of the price of the straw. The profitability of the operation is guaranteed for farmers within a radius of 30-35 km of the center, but profits are zero beyond 45 km. Thus, the distance between the source of the straw and the user is vital to the economic viability of the operation, tending to favor decentralized operations. A certain minimum-sized plant is required, however.

Straw is a much less convenient energy source than fuel oil. Investment costs are high for storage, energy conversion, and removal and treatment of residues. Despite these disadvantages, a good many straw-fired boilers have been sold in Western Europe in recent years similar to the one in Svendborg, Denmark. Denmark is a leading manufacturer of straw furnaces and probably also makes most use of them since the State pays up to 40 percent of the installation cost under the country's energy-saving program (*17*).

Energy from straw-fired boilers is used on both grain farms and smaller mixed crop and stock farms for domestic heating and frequently for heating farm buildings. However, many previously unknown negative factors are gradually coming to light in the course of using these installations. For example, the thermal yields from straw differ from year to year and from one field to the next.

Other dry agricultural residues, particularly corn cobs, are interesting for the production of energy, but present harvesting methods often leave the residues in the fields. This means existing harvesting equipment must be modified or new equipment designed.

Animal Waste. Livestock manure is the largest farm byproduct in the EC. According to recent estimates, conversion of all of the EC's animal waste to methane gas (bio-gas) would replace 3-5 percent of the region's total petroleum consumption. A number of technical, structural, and financial problems still have to be resolved before this energy source can begin to approach this level of output (*17*).

Anaerobic fermentation of animal waste requires an extremely high initial investment cost. Before a waste-processing plant is built, all other local sources of energy, the cost of imported fossil fuels, and the exact amount of energy needed to operate the digestor must be carefully evaluated in order to assure economic viability of the project.

Many types of fermentation installations are available, ranging from the most elementary with simple drums to fermentation tanks with very sophisticated control systems. The colder the region, the more likely the system will need to be heated, meaning additional cost. The type of installation chosen, and hence the investment commitment, depends on several factors, such as how the gas produced is used, the size of the herd, and the seasonal nature of the availability of the wastes. The distance between farms may also be an important factor to the extent that it determines the economic viability of centralized cooperative collection units.

The physical characteristics of bio-gas make it difficult and expensive to store. Liquefaction requires a certain pressure and temperature difficult to achieve and maintain in a rural environment. Storage in gas holders implies large volumes and very high costs. In view of these problems, bio-gas must be used immediately, either directly for heating or indirectly for operating stationary engines to produce electricty. Bio-gas cannot be used to run vehicles (*17*).

Another important consideration in bio-gas production is the collection and transportation of waste. Economic feasibility is restricted to intensive farming, or something close to it, where waste is concentrated in a small area and relatively easy to recover.

Pilot projects are currently underway in Germany, the Netherlands, and France. These projects are generally small installations of the nonindustrial type, and their viability is closely dependent on the type of installations already existing on the farm and on the real costs of adapting these to bio-gas production. Efforts are being made to reduce investment and operating costs as well as to bring gas output into line with energy requirements of the farm (*17*).

The minimum herd size for installing a separate bio-gas plant is currently thought to be at least 50 head of cattle or 400 pigs. About 45 percent of EC cattle are in herds of 50 or more, but only about 22 percent of pigs are in holdings of 400 or more (*17*).

Surplus Crops. Production surpluses or substandard products could also be used for energy production. Over the 1978-81 crop years, EC sugar production ex-

ceeded consumption by about 2.6 million tons a year. Taking into account average beet sugar yields per ha, the EC could use an estimated 386,000 ha of sugar beet area for energy production while remaining fully self-sufficient. This would yield about 1.8 billion liters of ethanol and replace about 2 percent of total fuel oil consumed in the EC (*17*).

Energy Crops. Energy crops can be used to generate motive power and heat. Prior to World War II, Western European agriculture provided most of its own energy needs in the form of crops to feed draft animals. Roughly one-third of the arable land in France, Germany, and Austria was devoted to the production of animal feed. Rapid mechanization and low fuel costs over the past 30 years have dramatically reduced the number of draft animals and virtually eliminated the need for such energy crops.

Since 1973, however, the rapid rise in energy prices has renewed interest in energy crops. In contrast to crop residues and animal waste, the cultivation of energy crops will significantly affect the structure of production and the allocation of agricultural land.

Energy crops must be carefully selected with the primary objective of obtaining the greatest possible quantity of energy under given agroclimatic conditions. Such crops may be either plants traditionally used for food, such as sugar beets, grains, colza, and sorghum, or nonfood crops, such as Mediterranean thistle, Jerusalem artichoke, and forest species. The latter group has a greater capacity for producing biomass, often under marginal agroclimatic conditions (*17*).

In the absence of governmental subsidies, the economic principle of profit maximization will determine whether or not energy crops will be produced. In other words, farmers must receive a return for their energy crops comparable to the return they could receive for the most profitable alternative crops. This will ensure net returns at least as high as those which they could obtain from any other use of their available resources. For economic reasons, Western European farmers have not yet been persuaded to switch even part of their land to the cultivation of energy crops.

The supply and demand for energy in all its forms determine a country's energy price structure at any point in time. The viability of ethanol production from energy crops, for instance, is determined by a comparison with the price of gasoline, its closest substitute. The higher the price of gasoline, the more likely that the production of energy crops will be profitable. Furthermore, the decision to produce such crops and to invest in processing installations depends not only on current price relationships but also on the stability of these relationships over the long term.

The growing of crops specifically for energy purposes involves ascertaining the types best suited to each region's agricultural conditions, establishing the appropriate farming techniques, and selecting varieties that use the greatest possible volume of solar energy.

The price of agricultural ethanol in the EC is generally comparable with the price of synthetic ethanol, with sugar beets the most important crop and France the largest producer. Other products, such as pototoes, cereals, and grapes, are also used, often as a means of using low-quality or surplus products (*17*).

The ethanol used at present as raw material in the chemicals industry of most industrialized countries is largely synthetic and made with petroleum products. However, fermentation ethanol from agricultural crops can be used for a wide range of chemical products. A number of countries, particularly Brazil and India, have large chemical industries based on the processing of fermentation ethanol.

Studies in France and the United States suggest that Jerusalem artichokes might be especially suitable for ethanol production. The conversion process is well known, but less well known are the technical and economic aspects of growing the crop. This crop can be grown in relatively unfertile land and appears to be suited to less favored rural areas. The tuber yields recorded in France range between 20 and 60 tons per ha, and about 85 liters of ethanol can be produced from 1 ton of tubers (*17*).

Using low-quality agricultural land rather than fertile land for energy crops is a possibility in many countries of Western Europe. In Spain, an estimated 200,000 ha of arid land (rainfall under 200 millimeters per year) could be very quickly put under energy crops.

Catch crops for energy purposes may be feasible in some countries of the region. These crops occupy the land between regular planting seasons. In the United

Kingdom, however, a recent study concluded that the country's relatively short growing season does not permit sufficient time between food crops (*17*).

Extension of the EC's beet area to produce ethanol could eliminate quotas and costly price supports now common in the region. In addition, such a switch may reduce the output of some surplus products, such as grains and dairy products, now occupying the land.

The feasibility of energy crops depends on the region's current degree of agricultural specialization and relative profitability. In Western Europe, a high degree of specialization has been created by heavy investment in plants and equipment specifically for particular types of production. The region's agricultural structure, therefore, is rigid. Vineyards and fruit and dairy areas cannot turn quickly or massively towards speculative energy production, despite surpluses. However, rather than continuing some costly subsidy programs, the EC could initiate programs to reorient these sectors towards the production of energy crops for which the market is unlimited (*17*).

Major scientific advances are not expected in the agricultural production of energy crops for at least 10 years. Scientists are working to reduce the vulnerability to genetic diseases of single crops grown over very large areas, characteristic of the main energy crops. Also, the method of production could be considerably changed and production costs lowered once photosynthesis research is successful in increasing the rate of solar energy conversion (*17*).

Energy crops, therefore, represent a genuine alternative source of energy, but except for the simplest forms of exploitation, assessing energy crops' potential is difficult.

Conclusion

Western European agriculture requires increasing amounts of direct and indirect energy. The high degree of mechanization, the intensive application of fertilizers and plant protection products, the use of specially bred and selected seeds and plants, and the rearing of livestock on concentrated feeds are all indications of the growing consumption of commercial energy. This commercial energy has been almost exclusively of fossil origin.

Although the energy used by agriculture is increasing, it still accounts for a very modest share of overall consumption of commercial energy supplies—between 4 and 5 percent in the EC and between 3 and 4 percent worldwide (*5*). Because agriculture's share of worldwide energy consumption is so small, an even further increase in the energy requirements of farmers will have a very limited effect on the overall demand for energy. However, any increase in the energy requirements of agriculture means greater dependence on petroleum and natural gas products as well as vulnerability to price rises.

Oil price increases have had little effect on the region's agriculture as compared with other sectors of the economy. This small effect is not only the result of the relatively small percentage of energy in total agricultural costs but the support given to agricultural commodity prices by the EC's Common Agricultural Policy. Future energy price increases, therefore, are not likely to significantly affect the performance and structure of the region's agricultural sector.

Experts believe that the current level of energy consumption could be reduced 10 to 15 percent by using specific economy measures, such as economizing on fertilizers, rational choice and use of machinery, thermal insulation techniques, and recovery of heat arising as a byproduct of certain types of farming (*5*).

Energy saving is not the only strategy with which agriculture could adjust to higher energy prices. Biomass in the form of animal and vegetable waste could be produced on the farm and used as a renewable source of energy, thus replacing to some extent nonrenewable fossil fuels. In addition, biomass in the form of crops produced specifically for energy purposes could supplement fossil fuels both in agriculture and in other sectors of the economy. Use could be made of familiar crops such as sugar beets and corn, but new types of crops could be developed. According to very cautious estimates, between 35 and 40 million toe could be produced from between 7 and 8 million ha of energy crops in the EC by the year 2000 (*5*).

The extraction of energy from biomass is like any other new activity in that it is very difficult to predict the level of production and marketing costs, the possible market outlets, and the degree of interdependence with other markets, both for the raw material and for

the end product. The extraction of energy from agricultural waste is already economically viable in some areas in very limited amounts. Energy crops, on the other hand, are still at the experimental stage.

Bibliography

(1) Bonny, Sylvie. *Estimations des Consommations Energetiques de Quelques Production.* Institut National de la Recherche Agronomique, Grignon, France, 1980.

(2) Bowes, R. C., and others. "The Potential of Energy Saving in Milking Parlours in the United Kingdom," *Energy Conservation and the Use of Renewable Energies in the Bio-Industries.* Ed. F. Vogt. New York: Pergamon Press, 1981.

(3) DeGraaf, H. J., and H. van der Wal. *Energieverbruik op Melkveebedrijven en de Reactie Van de Veehouder op Verdere Energieprijsstijging.* Rijksuniversiteit, Leiden, The Netherlands, 1981.

(4) Dvoskin, Don, and Earl O. Heady. *U.S. Agricultural Production Under Limited Energy Supplies, High Energy Prices, and Expanding Agricultural Exports.* Ames, Iowa: Iowa State Univ. Press, 1976.

(5) European Communities Commission. *Agricultural Situation in the Community: 1982 Report.* Brussels, 1981.

(6) ________. *Consumption of Energy in Agriculture in the European Community.* Study P. 219. Brussels, 1981.

(7) ________. *Energy Use in EEC Agriculture and Food Processing.* Brussels, 1981.

(8) ________. *European Community and the Energy Problem.* Brussels, 1983.

(9) ________. Comite Communautaire Du Reseau d'Information Comptable Agricole. *Consideration of the Development of Agricultural Incomes in the Community in Particular in Light of Updated FADN Results.* Brussels, 1981.

(10) European Communities Statistical Office. *Agricultural Price Indices (Output and Input).* Various issues. Luxembourg, 1978-80.

(11) ________. *Economic Accounts-Agriculture and Forestry.* Luxembourg, 1981.

(12) ________. *Purchase Prices of the Means of Agricultural Production.* Various issues. Luxembourg, 1978-81.

(13) ________. *Yearbook of Agricultural Statistics.* Luxembourg, 1982.

(14) Leach, Gerald. *Energy and Food Production.* International Institute for Environment and Development. London, 1975.

(15) National Farmers' Union of England, Wales and Scotland. *Report of the Working Party on Energy in Agriculture.* London, 1976 (Revised 1981).

(16) McNitt, Harold A. *The EC Market for U.S. Agricultural Exports: A Share Analysis.* FAER-179. U.S. Dept. Agr., Econ. Res. Serv., Mar. 1983.

(17) Organisation for Economic Co-operation and Development. *Biomass for Energy.* Paris, 1983.

(18) ________. *Energy Problem and the Agro-Food Sector.* Paris, 1982.

(19) ________. *The OECD Observer,* May 1982.

(20) ________, Committee for Agricultural Trade. *Study on Problems of Agricultural Trade.* Paris, 1982.

(21) ________, International Energy Agency. *Energy Balances of OECD Countries.* Various issues. Paris, 1975-81.

(22) ________. *World Energy Outlook.* Paris, 1982.

(23) ________, Working Party No. 1, Committee for Agriculture. *Agricultural Policy Issues and Developments.* Paris, 1981.

(24) M. Seligman. *Working Documents 1982/83.* Report to the Committee on Energy and Research. European Communities Commission, European Parliament, Brussels, 1982.

(25) M. M. Severnev, and F. P. Tsyganov. *Review of Existing Technological Processes in the Mechanization of Crop Production in Order to Reduce Energy Consumption.* Agri/Mech. Report No. 88. Food and Agriculture Organization of the United Nations/Economic Commission for Europe, Working Party on Mechanization of Agriculture, 1981.

(26) Slesser, M., and F. Wallace. *Consumption of Energy in Agriculture.* University of Strathclyde, Glasgow, 1982.

(27) Stansfield, J. R. *Fuel in British Agriculture.* National Institute of Agricultural Engineering. Bedford, United Kindgom, 1974.

(28) *Tenth World Energy Conference.* Istanbul, Turkey, Sept. 19-23, 1977.

(29) U.S. Department of Agriculture, Economic Research Service. *World Indices of Agricultural and Food Production,* 1972-81. SB-689. Aug. 1982.

(30) ________. *Agricultural Outlook.* AO-88. June 1983.

(31) White, D. J. ''Efficient Use of Energy in Agriculture and Horticulture,'' *The Agricultural Engineer.* 1979.

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Developments in the Common Agricultural Policy of the European Community examines the directions the EC's Common Agricultural Policy (CAP) may take in order to avert a budget crisis and the implications for trade with the United States and other countries. According to authors Timothy Josling and Scott Pearson, the ever-increasing farm subsidies prescribed by the CAP will seriously harm the EC's ability to meet other policy needs and will hinder enlargement of the Community to include Spain and Portugal. EC policymakers may have to either keep prices low directly or with producer taxes, or limit quantities covered by subsidies. FAER-172. June 1982. 88 pp. $5.50. Order SN: 001-000-04271-8.

Sweden's Agricultural Policy, one of the few English sources on contemporary Swedish agricultural policy, covers the major provisions of Sweden's 1982-84 farm program. "An accurate and concise presentation," says the Swedish Ambassador to the United States. Sweden's policy objectives are to reduce Government subsidies for agricultural exports (a major aim of U.S. world trade policy), to cut back on consumer food subsidies and farmer compensation programs, and to make the levies on imports more responsive to market conditions. Chief U.S. exports to Sweden include fruits, vegetables, nuts, and tobacco, which are relatively unaffected by Swedish import levies, and grains. FAER-175. October 1982. 44 pp. $4.25. Order SN: 001-000-04300-5.

The EC Market for U.S. Agricultural Exports: A Share Analysis assesses the market potential for all major U.S. agricultural exports to the EC. Author Harold McNitt finds that the United States will continue as a leading supplier to the EC of soybeans, sunflowerseed, corn and corn gluten feed, peanuts, citrus pulp, some animal products, and soybean meal. EC trade policies, however, sharply restrict imports of most fruits and vegetables, processed food, and meats. FAER-179. March 1983. 92 pp. $5.00. Order SN: 001-000-04326-9.

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